

## CLAIMS:

1. An apparatus for optical modulation, the apparatus comprising:  
an optical waveguide (10); and  
a microwave waveguide (12), said microwave waveguide (12) having an  
electro-absorptive material (14) sized and placed such that, for an optical wave  
of interest guided in said optical waveguide (10), the electro-absorptive  
material (14) is located in an evanescent region (16) occupied by the optical  
wave's evanescent tail when the optical wave is being guided in said optical  
waveguide (10).
2. The apparatus recited in claim 1, wherein  
said optical waveguide (10) includes  
a substrate (18);  
an N-contact layer (26);  
an upper semiconducting cladding layer (20) disposed between  
said substrate (18) and said N-contact layer 20;  
a semiconducting core layer (22) disposed between said substrate  
(18) and said upper semiconducting cladding layer (20); and  
a lower semiconducting cladding layer (24) disposed between  
said substrate (18) and said semiconducting core layer (22); and  
wherein N-contact layer (26) and an upper part of upper  
semiconducting cladding layer (20) are etched down to form a ridge.
3. The apparatus recited in claim 2, wherein  
said microwave waveguide (12) includes  
two N-contacts (28) disposed on said N-contact layer (26);  
said electro-absorptive material is disposed between and  
equidistant from said N-contacts (28) on said ridge of said upper

semiconducting cladding layer (20);

a P-contact layer (30) disposed on said EA material (14); and

a P-contact (32) disposed on said P-contact layer (30).

4. The apparatus recited in claim 3, wherein

5 said N-contacts (28) are disposed at each outer edge of said ridge of said N-contact layer (26).

5. The apparatus recited in claim 2, wherein

said microwave waveguide (12) includes

10 two N-contacts (28) disposed on said N-contact layer (26), each of said N-contacts (28) being disposed on either side of a main mode region (34) and said evanescent region (16) of said optical waveguide (10), wherein said N-contact layer (26) and said upper semiconducting cladding layer (20) have an etched-away area between each of said N-contacts (28) and said main mode region (34) and said evanescent region (16) of optical waveguide (10) to  
15 form a ridge;

said electro-absorptive material (14) disposed on said N-contact layer (26) on said ridge;

a P-contact layer (32) disposed on said electro-absorptive material (14) on either side of a top surface of said electro-absorptive material  
20 (14);

two insulators (35) disposed on said N-contact layer (20) in contact with side surfaces of said electro-absorptive material (14), wherein each of said insulators (35) is in contact with said P-contact layer (32), and wherein said P-contact layer (32) and said insulators (35) form an inverted V-  
25 shaped groove with a truncated tip at said top surface of said electro-absorptive material (14); and

a P-contact (36) disposed in said V-shaped groove and extending at least to a top surface of each of said insulators (35).

6. The apparatus recited in claim 5, wherein  
said N-contacts (26) are disposed at each edge of said etched-  
5 away areas opposite said ridge formed by said etched-away areas.

7. The apparatus recited in claim 5, wherein said apparatus  
has a microwave modulation voltage less than or equal to 0.3 V,  
has an optical saturation power of equal to or greater than  
100mW,  
10 has an operating bandwidth equal to or greater than 40 GHz,  
has an effective thickness of EA material (14),  $d_{i,eff}$ , less than or  
equal to 0.1  $\mu\text{m}$ , and  
has a microwave propagation loss per unit length,  $\alpha_{rf}$ , less than or  
equal to 3 dB/mm;  
15 is capable of having a microwave wave guide in microwave  
waveguide (12) and an optical wave guided in optical waveguide (10) wherein  
a phase velocity of the microwave wave and a phase velocity of the optical  
wave are equal; and  
microwave waveguide (12) has an impedance capable of being  
20 matched to a microwave driver, the microwave driver being capable of supply  
a microwave wave to be guided in said microwave waveguide (12).

8. The apparatus recited in claim 1, wherein  
said electro-absorptive material (14) is a multiple quantum well  
material.

9. The apparatus recited in claim 1, wherein  
said electro-absorptive material (14) is a Franz-Keldysh material.
- 5 10. The apparatus recited in claim 1, wherein  
said electro-absorptive material (14) is a group III-V compound  
material.
11. The apparatus recited in claim 1, wherein  
said electro-absorptive material (14) is InGaAsP.
- 10 12. The apparatus recited in claim 1, wherein  
said electro-absorptive material (14) is GaInAlAs.
13. A method for optical modulation, said method comprising the  
steps of:  
guiding an optical wave in an optical waveguide (10), said optical  
wave having an evanescent tail; and  
15 applying a modulation voltage to said evanescent tail.
14. The method recited in claim 13, further comprising a step of:  
positioning an electro-absorptive material (14) in said evanescent  
tail of said optical wave; and  
wherein said step of applying a modulation voltage to said  
20 evanescent tail is performed by applying said modulation voltage to said  
electro-absorptive material (14).
15. The method recited in claim 13, wherein  
said modulation voltage is analog.

16. The method recited in claim 13, wherein  
said modulation voltage is digital.
17. The method recited in claim 13, wherein  
said step of guiding said optical wave includes direct coupling a single  
mode fiber optical wave into said optical waveguide (10).
18. The method recited in claim 13, wherein  
an optical confinement factor of said electro-absorption material  
(14),  $\Gamma$ , between and 1% and 5% enables the optical modulation of an optical  
power equal to or greater than 100 mW.